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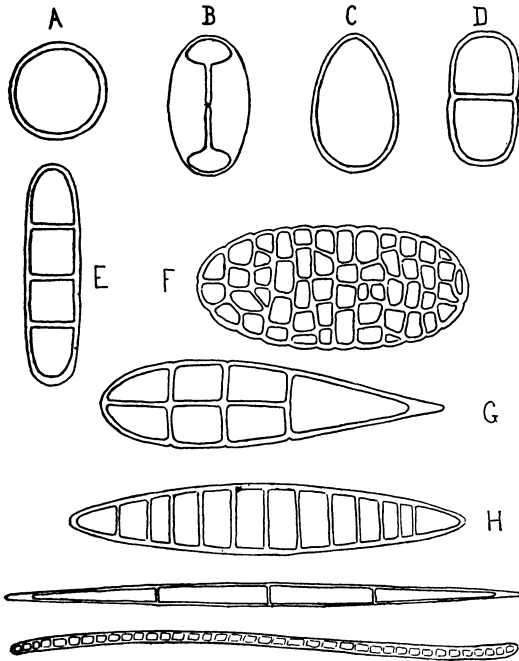


Fig. 17. Forms of spores. A, globose; B, ellipsoid; C, ovoid; D, oblong; E, dactyloid; F, oblong-ellipsoid; G, cymbiform; H, fusiform; I, acicular; J, cylindrical. A and C are simple; D, bilocular; E and I, quadrilocular; H and J, plurilocular; B, polar-bilocular; F and G, muriform. (Original.)

the value of the divisions should be carefully ascertained for each objective. Thus equipped it is an easy matter to measure the spores, and these measurements should be recorded on the label of the specimen together with a drawing of a spore, showing outline, number of septæ and (by shading) the presence of color.

(To be continued.)

which vary from .007 to .012 millimeters in length and from .005 to .007 in breadth we should write the expressions  $\frac{7-12}{5-7}$  mic. or  $\mu$ .

As soon as possible after an unknown specimen is collected it is desirable to examine the spores. Having made a thin section of the apothecium or removed a small portion of the hymenium, it may be treated with a little potassic hydrate on the slide and crushed somewhat under the cover glass. Iodine is sometimes useful as a coloring agent. It gives a yellowish or brownish tinge to protoplasm and turns the thekes blue. The microscope should be provided with an eyepiece micrometer and

## WHAT TO NOTE IN THE MACROSCOPIC STUDY OF LICHENS II.

BRUCE FINK.

### VARIATION IN LICHENS.

Before passing to a consideration of the gross morphology of the fruits of lichens, it may be stated that lichens are scarcely more varied as to form, size and color than many undoubted morphological units of the plant kingdom, and that the variations are by no means so great that these characters can not be depended on in the description and determination of species and

varieties. The student will find in some works on lichens that, in an attempt at brevity, there has been an omission of some characters that are very essential to successful determinations and that in others the same end is gained by a dogmatic statement regarding form, size and color, which would lead the beginner to expect in the plants a like constancy, which by no means exists.

#### THE APOTHECIUM.

Likewise in the fruit, or apothecium, the main features of gross morphology are size, form and color: and these will now be taken up and considered, one at a time. The apothecia are usually superficial and large enough to be seen easily with the unaided eye. But in some instances they are so small that they can be made out with difficulty with the hand lens. Or they may be immersed in the thallus and indicated at the surface by a slight elevation or depression as a disk or ostiole, or they may, when immersed, be scarcely discernable in any way except in sections of the thallus. From .1 to 5 mm. is well within the range for diameters of apothecia.

The apothecia are most commonly saucer-shaped or some slight modification of this form as when the disk is flat or somewhat convex instead of concave. In some instances the disk becomes very concave, when finally the apothecium may be called cup-shaped, and in others it is strongly convex, finally giving the apothecium a more or less spheroidal form. In all of these forms, the outline of a transverse section of apothecium would usually be very nearly a perfect circle; but the form may become irregular as growth proceeds, so that at maturity this outline is quite irregular. In other lichens the apothecia are of some other form from the beginning. Thus there are the elongated and often branched forms such as are found in *Graphis*, and the difform or variously irregular forms as in *Arthonia*. Again, some apothecia are produced into a well developed perithecium, and these usually approximate a spherical form.

#### THE DISK.

In those lichens in which the exciple is not produced into a perithecium, the upper surface of the apothecium is naked, except for a very thin film of thallus, which may persist as an epithecium, a structure not mentioned in the descriptions of species. This upper and essentially naked surface, whether flat or more or less strongly concave or convex, forms the disk. The outline of the disk, then, may be circular or variously elongated or irregular, varying in this respect with the form of the apothecium as a whole. In color the disk varies considerably even in the same species. It is usually light colored in its early development and commonly becomes darker as it reaches maturity. The final color, then, may be a light or darker flesh-color or a light or darker shade of yellow, orange, red, brown, chestnut, olive, or even black. And the color is very seldom the same as that of the thallus, but the surface may be pruinose with a usually white powder, concealing the essential color of the disk.

#### THE EXCIPLE.

Below the disk is the hymenium, which may easily be made out in sections with the hand lens. This structure is usually lighter in color than the

disk and is composed of paraphyses and asci. Below the hymenium is the hypothecium, often darker in color than the hymenium above it, so that the line of demarkation between the two structures may easily be made out with the hand lens. The hymenium and the hypothecium are hardly to be studied macroscopically, and are mentioned here mainly that another structure, the exciple, may be located with reference to these two structures. Then the exciple may be said to form the saucer-shaped or cup-shaped covering around the hymenium, being an upward continuation of the hypothecium on all sides. Such rather is the *proper exciple*, but there is sometimes outside of this, or more often replacing it, what is known as a *thalloid exciple*. This last is similar to the thallus in structure and usually of the same color, while the proper exciple is never of the same color as the thallus and usually approximates in color the disk.

Either of the exciples may be permanently absent, and either or both may be quite evanescent and only to be seen in young apothecia. But usually one is permanent or tardily disappearing so that it may be seen readily with the eye or the lens, and the nature and degree of development and permanence is of considerable value in the classification of lichens, even to the determination of species. The perithecium has been mentioned, and this is simply a produced exciple found in some lichens, and growing completely around the upper part of the hymenium, except the small opening or ostiole at the summit. The margin of a proper exciple is usually about at the level of the outer margin of the disk, or it may be somewhat raised above the disk. This margin is almost always quite entire, while the margin of a thalloid exciple is frequently crenulate, crenate, variously branched, ciliate or irregular.

#### POSITION OF THE APOTHECIA.

Perhaps the only thing yet remaining to be said regarding the fruit, is something concerning its position with reference to the thallus. Sometimes the apothecium is raised on a slender upward extension of the thallus, a short stalk or pedicel, quite different from the podetium of a *Cladonia* or the stipe of a *Calicium* and most frequently met in the larger foliose lichens. The stalk may be absent and the apothecium attached to the thallus at the centre of the ventral side of the apothecium. Such apothecia are said to be sessile. Again, the apothecium may be more closely attached to the thallus by all of its lower side, and then it is said to be adnate. Finally, the apothecia may be more or less immersed in the thallus, sometimes deeply, so that, when the disk is more or less over-grown by the thallus or by a perithecium, the structure is often quite obscured.

The development of the apothecium begins below the surface of the thallus, and the tendency in general is to become more and more superficial as maturity is reached. So it comes about that the apothecium sometimes remains permanently more or less immersed, or more commonly becomes superficial or stalked. And somewhat varying conditions as to position with reference to the thallus may be expected in many species.

#### STIPES AND PODETIA.

Very naturally, we may consider next in order podetia and stipes. Both are to be regarded as structures developed originally for the purpose of supporting the spore-bearing organ, or apothecium, and raising it up into the air. But in the *Cladonias* and *Stereocaulons*, a secondary function has replaced the original to some extent, and the original stipe, a structure devoid of algal cells as that of the *Caliciums*, *Cyphelioms* and *Coniocybes*, has in these first two genera taken to fostering the algal cells, thus becoming a true thallus, whose vertical expansion and often extensive branching greatly increases the area of surface below which the algae may find protection. Thus the stipe differs from the podetium in that the former is devoid of algal cells and the latter not, the former belonging to the fruiting tract and the latter, doubtless by modification, more properly to the vegetative tract.

#### RHIZOIDS AND CILIA.

And after thus considering the gross morphology of the thallus and the fruiting tracts, there are a number of less conspicuous structures, less constantly present even than the fruit, or not so often to be seen with eye or lens, but still sometimes quite apparent. First among these may be mentioned the rhizoids and cilia. The rhizoids are found on the ventral side of most foliose thalli and serve as attaching organs. They appear to the eye as root-like bodies, varying in color from white to black. We say root-like, but do not call them roots, since they differ from true roots very much as to minute morphology. The cilia are like the rhizoids in structure, but are found on the upper surface of the thallus or along the margins.

The hyphal rhizoids of the crustose lichens are quite different morphologically, but these need receive no attention here on account of their minute size. However, it is in order to state that the functions of cilia are to retain drops of water and gradually absorb them, and sometimes when quite numerous, to protect against cold and dust. Closely related to rhizoids is the simple attaching organ on the ventral sides of the thalli of *Gyrophoras*, *Umbilicarias*, and many *Endocarpons*. This structure is known as the umbilicus.

#### SOME OTHER STRUCTURES.

Spermagonia, soredia, cephalodia and cyphellae are structures which occur on the surface of thalli. The spermagonia are organs of doubtful nature and function, sometimes quite conspicuous as dark colored spots on the upper surface of the thallus as in some *Parmelias* and other large foliose lichens; but these structures are more often minute and of the color of the thallus so that they appear only in sections. They were formerly thought to be of considerable value in the determination of species. The soredia are little powdery masses, usually whitish in color, and scattered over the surface of the thallus as in *Pyxine sorediata* and many other lichens. Cephalodia are wart-like bodies found on the upper surface of some lichens as in *Peltidea aphthosa*, or within the thallus, as in some other lichens. Cyphellae are small pits or depressions in the lower surface of some foliose lichen thalli as in some *Stictas* and *Stictinas*. The further consider-

ation of the various structures and their functions belong rather to minute morphology and to physiology.

Finally in some lichens the so-called hypothallus is conspicuous to the eye or with the lens. This is true of some members of the genus *Pannaria*. For instance, in *Pannaria nigra*, this structure appears as a bluish-black ring all around the thallus. Its nature is not well understood, though possibly it is a remnant of some lichen that the *Pannaria* has over grown. Some of the older authors considered the rhizoids a portion of the hypothallus.

#### CONCLUSION.

In these days of microscopes and microscopic study, there is some danger that the beginner will actually come to think that there is little to be seen in lichens and other plants below the spermatophytes without using a microscope. The object of the present paper is, then, to call attention to the very many features of lichen-morphology which may readily be observed in the field, with no other aid than the eye, or this supplemented by a good hand lens. The points considered in the above pages are well known to lichenists, but we do not know where they have previously been brought together in compact form so that the beginner may have them for ready reference.

It has not been possible to give, in so brief space, every feature of the gross morphology of lichens and all variations, but the statements are intended rather to be suggestive. It is believed that, if the student will repeatedly read the suggestions given, and then observe more carefully than ever before, he will soon become convinced that the lichens have more definite features of gross morphology than he had previously supposed, and that these features require careful attention at his hands. It is well known that a number of the readers of the *BRYOLOGIST* are becoming interested in lichens, and it has seemed appropriate that such statements as are given herein should be brought to the attention of these persons as an aid to careful observation.

Grinnell, Iowa.

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#### BOOK REVIEWS.

##### SECOND EDITION DIXON & JAMESON.

J. P. NAYLOR.

A somewhat careful comparison of the last edition of Dixon & Jameson's Student's Handbook of British Mosses, with the Manual, Barnes' Keys, and the file of the *BRYOLOGIST*, shows that, of the six hundred and two species described in the Handbook, four hundred and thirty-three are American forms. This is a little more than seventy-two per cent. Of the one hundred and fifteen genera all but six are found in the United States, and of these six, only one has more than one species. The British Moss flora seems to be particularly rich in one species genera; there being forty-four of them which contain but a single species.

The fact that the genera are so largely American, taken in connection with the plates and the admirable descriptions, makes the book most valu-